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ABSTRACT

Highlights of "Research and Development in Industry, 1979" are presented in this report, including summaries on total research and development (R&D) funds, federal and industrial funds, funding for applied and basic R&D, energy R&D, and R&D scientists and engineers. (SK)

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SCIENCE RESOURCES STUDIES HIGHLIGHTS

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Real Growth in Industrial R&D Performance Continues into 1979

The statistical data presented in this report were collected for the National Science Foundation by the Bureau of the Census in the annual Survey of Industrial Research and Development. Remarks attributed to company officials were based on discussions with several of the leading R&D-performing companies in the major industries.

Highlights

• U.S. firms spent nearly $38 billion on research and development during 1979, 13 percent above the level reported for the preceding year (table 1). In constant 1972 dollars, the gain was 4.5 percent. The industrial sector, historically the major performer of research and development in the United States, spent approximately 70 percent of total U.S. R&D outlays in 1979. Industrial R&D expenditures increased faster than the rate of inflation after 1975, registering an average annual real growth rate of 4.7 percent through 1979.

• Increases in both company and Federal funds contributed to the 1975-79 upward trend in industrial R&D expenditures, although the former share grew at a significantly higher rate than the Federal portion in each of those five years. In 1979, company-financed research and development rose by 15 percent, whereas Federal expenditures increased 11 percent. According to industry officials, firms in highly competitive technology-intensive industries are investing heavily in research and development as part of a long-term strategy to ensure, foster, and maintain corporate growth.

• For the fourth consecutive year, the automotive industry led the other major R&D-performing industries with an increase in total R&D expenditures of 16 percent over the 1978 level. Industry representatives attribute the rise in R&D activity to the development of more competitive fuel-efficient vehicles and devices to meet more stringent emissions control standards. Of the five leading R&D-performing industries, aerospace companies reported the largest percentage gain in company-financed research and development — up 22 percent (13 percent in constant dollars) in 1979. These additional outlays largely reflect efforts underway to develop supercapacity commercial airliners.

• Of the three types of R&D activity, basic research exhibited the highest average annual increase — 14 percent between 1977 and 1979. Applied research and development each rose by 12 percent. Basic research, as a percent of total research, climbed from 3.0 percent to 3.2 percent, marking the first time this ratio has risen since 1962. Of the five major R&D-performing industries, the machinery industry (which includes computer firms) registered the largest average annual increases in both basic and applied research, reflecting the exceedingly high level of innovative activity occurring in that industry.

• During 1979, total industrial outlays for energy-related research and development rose dramatically — 22 percent — to a total of $3.7 billion. Greater emphasis is being directed toward the exploration of new potential sources of supply and improvement of energy efficiency. Industry performance of research and development focusing on nonconventional sources of energy, e.g., solar and geothermal, as well as on conservation and utilization, gained momentum during 1979. The increase was 45 percent, higher than the rates reported in any of the three preceding years.

• Industry employed a record 444,500 full-time-equivalent (FTE) R&D scientists and engineers in January 1980. The total number of these R&D professionals had climbed steadily after 1976 at an average annual rate of 5 percent. This series of increases is the largest since the survey began and follows periods of actual decline or little growth in the employment of R&D scientists and engineers during the early and midseventies. In 1979, the electrical-equipment industry exhibited the largest percentage increase — 9 percent — in the hiring of professional R&D personnel.

(Prepared in the Industry Studies Group, Division of Science Resources Studies)

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Table 1. Selected Industrial R&D Data

[Dollars in millions]

Industry	SIC Code	Total R&D Funds		1979 R&D Funds					R&D Scientists & Engineers	
		1979	1978	Federal	Company	Basic Research	Applied Research	Development	January 1980	January 1979
Total		$37,606	$33,164	$12,342	$25,264	$ 1,188	$ 7,114	$29,304	444,500	421,000
Food and kindred products	20	475	429	(')	(')	(')	(')	(')	7,500	7,800
Textiles and apparel	22, 23	92	84	(')	(')	3	21	68	1,800	1,800
Lumber, wood products and furniture	24, 25	148	133	2	146	6	41	101	2,200	2,200
Paper and allied products	26	454	391	(')	(')	20	113	321	7,600	7,200
Chemicals and allied products	28	4,010	3,534	379	3,631	367	1,674	1,969	50,900	48,300
Industrial chemicals	281-82, 286	2,018	1,820	360	1,658	202	860	956	22,100	21,600
Drugs & medicines	283	1,431	1,270	(')	(')	143	631	657	20,700	19,700
Other chemicals	284-85, 287-89	561	444	(')	(')	22	183	356	8,100	7,000
Petroleum refining and extraction	29	1,224	1,060	142	1,082	74	559	591	10,700	10,700
Rubber products	30	551	488	(')	(')	23	115	413	9,200	8,000
Stone, clay, and glass products	32	348	321	(')	(')	44	82	222	5,000	5,200
Primary metals	33	613	549	33	580	28	299	286	8,400	8,200
Ferrous metals and products	331-32, 3398-99	293	266	5	288	12	136	145	3,600	3,700
Nonferrous metals and products	333-36	320	283	28	292	16	163	141	4,800	4,500
Fabricated metal products	34	445	396	36	409	5	109	331	7,700	7,500
Machinery	35	5,142	4,579	673	4,469	112	674	4,356	63,300	61,000
Office, computing and accounting machines	357	3,597	3,235	627	2,970	95	395	3,107	43,000	42,200
Electrical equipment	36	7,584	6,591	3,224	4,363	220	1,173	6,191	94,700	86,600
Radio and TV receiving equipment	365	60	51	—	60	(')	(')	10	(')	(')
Electronic components	367	1,006	824	(')	(')	7	138	861	(')	(')
Communication equipment	366	3,767	3,189	1,543	2,224	185	598	2,224	45,200	42,400
Other electrical equipment	361-64, 369	2,751	2,527	(')	(')	(')	(')	2,336	31,800	29,400
Motor vehicles and motor vehicles equipment	371	4,320	3,718	628	3,692	16	(')	(')	34,400	32,900
Other transportation equipment	373-75, 379	152	131	(')	(')	(')	(')	100	1,800	2,000
Aircraft and missiles	372,376	8,414	7,680	6,132	2,281	73	906	7,435	87,300	86,400
Professional and scientific instruments	38	2,024	1,713	223	1,801	31	246	1,747	28,400	24,000
Scientific and mechanical measuring instruments	381-82	592	476	35	557	18	(')	(')	11,400	9,000
Optical, surgical, photographic, and other instruments	383-87	1,432	1,237	188	1,244	13	(')	(')	17,000	15,000
Other manufacturing industries	21, 27, 31, 39	293	273	7	286	52	(')	176	4,300	4,800
Nonmanufacturing industries	07-17, 41-67 737, 739, 807, 891	1,317	1,094	645	672	64	574	679	19,300	16,400

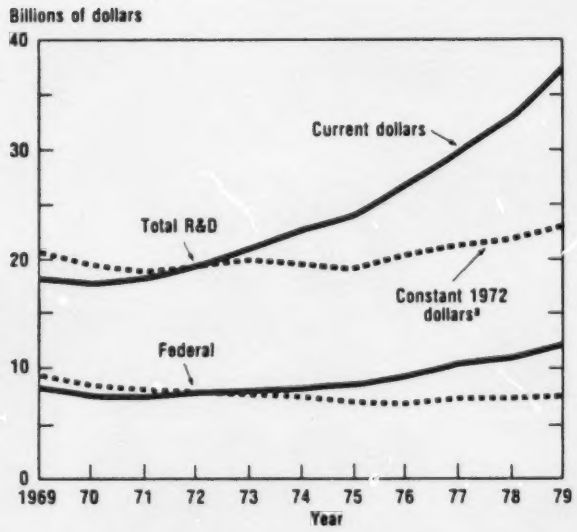
'Not separately available but included in total

SOURCE: National Science Foundation

Total R&D Funds, 1979

U.S. firms continued to expand their R&D programs during 1979, when total industrial R&D expenditures rose to almost $38 billion, 13 percent higher than the amount spent the previous year. This represents a gain of 4.5 percent in constant dollars, which paralleled the average annual real-growth rate registered between 1975 and 1979.[1] The steady upward trend of investment in industrial research and development during the last half of the seventies presents a sharp contrast to the first half of the decade when constant-dollar expenditures suffered a 2-percent decline. The average rate of inflation was approximately 6.5 percent during both of these periods (chart 1).

Chart 1. Industrial R&D performance



[a]The GNP implicit price deflator was used to convert from current to constant dollars

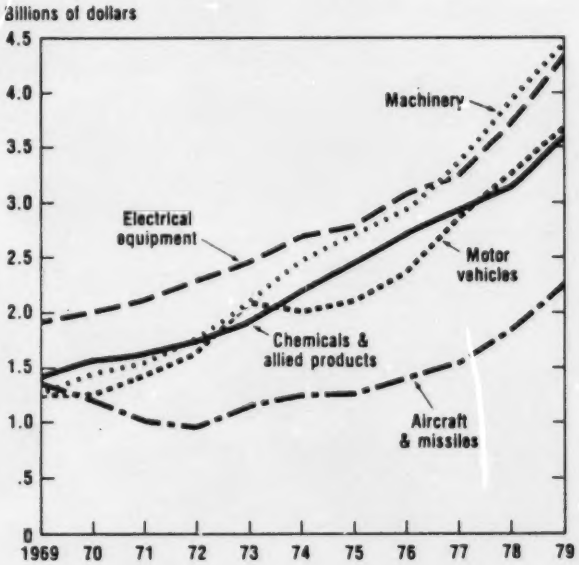
SOURCE: National Science Foundation

COMPANY FUNDS

Almost three-fourths of the $4.4 billion increase in industrial research and development reported for 1979 is attributable to substantially higher funding from companies' own financial resources. Firms spent a total of $25 billion, or 15 percent more on industrial research and development than in 1978 — a constant-dollar gain of 6 percent. The company proportion of the total industrial R&D effort gradually rose — from less than one-half in 1963 to two-thirds in 1979. The latest series of real increases beginning in 1975 and averaging 5.8 percent per year has reinforced this trend.

In 1969, the machinery industry ranked fourth in total company R&D outlays. Between 1969 and 1979, however, growth of the internally financed R&D expenditures of this industry — which includes computer firms — outpaced the other major R&D-performing industries so that by 1979 it was leading in total company R&D performance (chart 2). The electrical-equipment industry spent the second highest amount of its own funds on research and development in 1979. Representatives of these industries agree that a combination of several factors triggered the upsurge in company expenditures on research and development: rapidly advancing technology; escalating demand; and expanding, and increasingly more diverse and competitive markets. Firms manufacturing computers and computer software, and electronic and communications equipment, had to allocate greater resources to assure the continual development of technically more sophisticated products and new applications for existing ones.

Chart 2. Five leading industries in company R&D Funds



SOURCE: National Science Foundation

FEDERAL FUNDS

The Federal Government increased funds to industry for research and development by 11 percent in 1979. When adjusted for inflation, the gain was 2 percent. This compares favorably with the 1-percent decline reported for the previous year, but is slightly below the 3-percent average annual growth rate registered during the 1975-79

[1]Average annual percentage changes are based on compound rates of change.

period. The aircraft and missiles industry expended half of these funds, mainly through contracts with the Department of Defense (DOD) and the National Aeronautics and Space Administration (NASA). Federal funds for research and development performed by this industry, however, rose during 1979 by only 5 percent — well below the rate of inflation. In contrast, public monies used for research and development by the electrical-equipment industry, which received the second highest allotment from the Government (one-quarter of which is provided by the Department of Energy (DOE)), climbed 13 percent. The automotive industry reported the largest percentage increase in Federal monies for R&D activities — 40 percent — although these Federal funds (supplied primarily by DOD) accounted for a relatively small portion, only 15 percent, of this industry's total R&D effort in 1979.

The slowdown in both military-related research and development supported by DOD, and NASA funding for the development of the space shuttle, was somewhat counterbalanced by a sharp increase in industrial R&D activities financed by DOE. These additional funds, however, were not sufficient to offset the sluggish growth in the DOD and NASA budgets for industrial research and development, which resulted in a constant-dollar decline of 22 percent during 1969-79 in total Federal financing of industrial research and development.

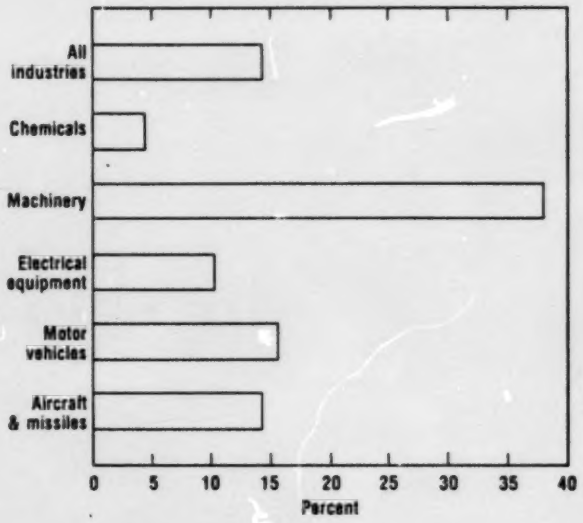
Research and Development by Character of Work

Firms invested over $29 billion in development during 1978-79, comprising 78 percent of total industrial R&D expenditures. Of the remaining portion, $1.2 billion was spent on basic research and $7.1 billion on applied research. During 1977-79, industrial R&D outlays for basic research averaged an annual gain of 14 percent, whereas applied research and development each increased at an average annual rate of 12 percent.

Basic research usually requires a long-term commitment of both financial resources and personnel. The proportion of total industrial R&D expenditures devoted to basic research gradually declined from the peak of 4.3 percent reached in 1962 to 3.0 percent in 1972. After hovering at that level for several years, basic research as a percent of total R&D outlays rose to 3.2 percent in 1979, signifying somewhat greater willingness on the part of companies to undertake basic research and assume the long-term risks associated with this type of investment.

The chemical industry was the leading performer of both kinds of research, spending 25 percent of total-industry expenditures on research in 1979. Of the five principal R&D-performing industries, the machinery industry, led by the office-, computing-, and accounting-machine sector, exhibited the largest percentage average annual increases in both basic and applied research — 38 percent and 23 percent, respectively — during 1977-79 (chart 3). Industry representatives cite a twofold explanation to account for this heightened activity: accelerating

Chart 3. Average annual increases in expenditures for basic research in the five leading R&D performing industries: 1977-79



SOURCE: National Science Foundation

technology and large anticipated payoffs. Expectation of substantial returns is high, given the multitude of new markets for both the diversity of products and additional applications of recently discovered technologies.

The aircraft and missiles industry is the largest performer of development, spending over $7 billion in 1979. Corporate officials point to foreign competition as a major factor underlying the decision of domestic aircraft manufacturers to allocate more of their own resources for development. Both domestic and foreign companies have been engaged in the development of commercial aircraft designed to transport larger numbers of passengers. The electrical-equipment industry showed the largest average annual increase in development during 1977-79 — 14 percent. More than one-half of these additional funds was utilized by companies producing communications equipment.

Energy Research and Development

A total of $3.7 billion was spent by industry on energy research and development during 1979, a gain of 22 percent over the previous year. During 1975-79, energy R&D expenditures rose at an average yearly rate of 13 percent in constant dollars. Energy-related projects accounted for 10 percent of the total industrial R&D effort in 1979, up from 4 percent in 1972. Energy research and development has assumed a major role in the search for solutions that will lessen this country's dependence on imported oil. The focus of this effort has been on improving energy efficiency, promoting conservation, and developing new

sources of supply. To achieve these objectives, both companies and the Federal Government were channeling resources into energy R&D projects with the latter supplying roughly one-third of the total outlays during 1973-79. The electrical-equipment industry, which was the leading performer of energy research and development, received approximately one-half the Federal monies available during 1979. These funds were used in part to finance nuclear research conducted at federally funded research and development centers (FFRDC's) operated by firms in this industry. The petroleum industry reported the second highest total in 1979. Unlike the electrical-equipment industry, the energy research and development undertaken by oil companies was internally financed (84 percent) (chart 4).

Data for 1979 reveal a substantial increase — 45 percent — over the previous year in funds expended for research and development to improve conservation and utilization as well as to explore what are generally considered to be nonconventional sources of energy — geothermal and solar (chart 5). Funding for these categories of energy research and development approached that for fossil fuels and nuclear research and development combined in 1979, and companies project that it will exceed expenditures on those sources during 1980. Spending for research and development on fossil fuels — led by the increase in R&D expenditures for synfuels — rose by 19 percent during 1978-79. Both industry and the Federal Government, however, reduced their commitments to nuclear research. The decline amounted to 2 percent in 1979, but, according to companies' 1979 projections nuclear research and development was expected to decrease another 6 percent in 1980.

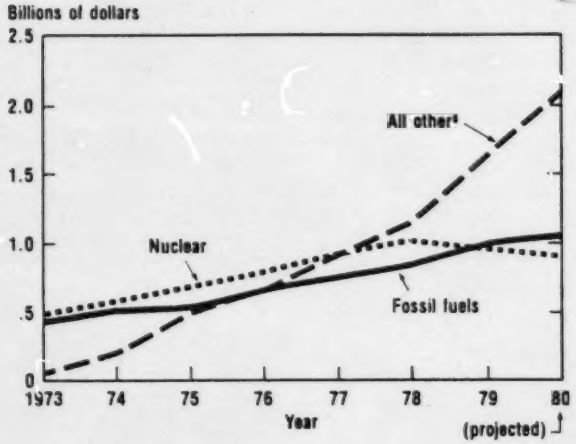
R&D Funds as a Percent of Net Sales

The ratio of total R&D outlays to net sales for all manufacturing industries was 3.1 percent in 1979, showing a slight drop of one-tenth of 1 percent from the previous year. This ratio gradually declined during the midsixties and early seventies from the peak of 4.5 percent reached in 1963 but has remained virtually unchanged since 1974. Because company funds as a percent of net sales has shown a high degree of stability since 1963, this percentage decrease resulted from the slowdown in Federal support of industrial research and development. Individual industry data reveal little change during 1978-79 with one major exception: The ratio of research and development to net sales in the automotive industry jumped from 3.2 percent to 3.8 percent. This increase is attributable to exceptionally higher R&D expenditures coupled with slower growth in net sales during 1979.

R&D Scientists and Engineers

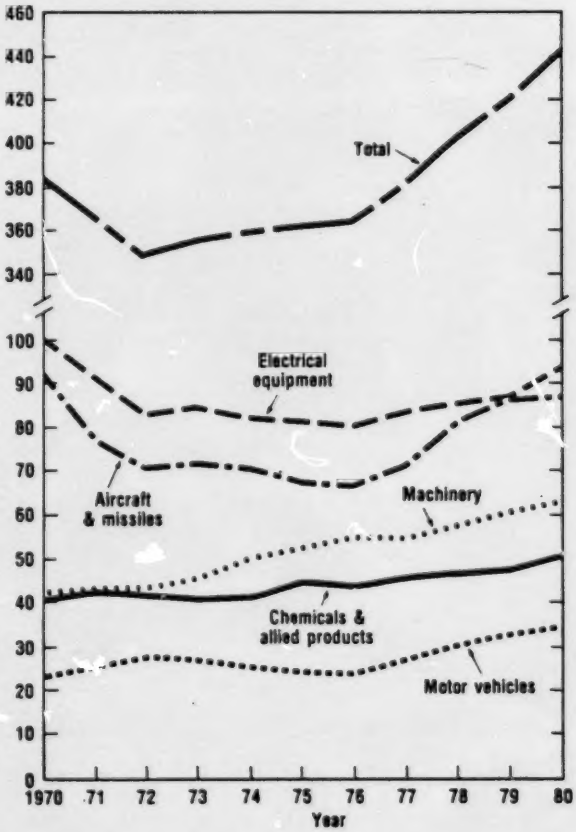
The total number of FTE R&D scientists and engineers employed by industry reached a new all-time high — 444,500 — in January 1980 (chart 5). Spiraling nationwide demand for these technical personnel, especially

Chart 4. Industrial R&D expenditures by energy source



[1]Includes geothermal and solar sources, and energy-conservation and -utilization.
SOURCE: National Science Foundation

Chart 5. FTE[2] R&D Scientists and engineers by industry



[2]Full-time-equivalent.
SOURCE: National Science Foundation

engineers, is reflected in industry data for the years 1975 through 1979, which show the longest period and highest annual percentage increases, averaging 5.1 percent, since the survey began in 1957.

Three-quarters of the total number of R&D scientists and engineers working for companies in 1979 were employed by the top-five R&D-performing industries. The electrical-equipment and aircraft and missiles industries reported the highest levels of R&D professionals employed during 1979 with 94,700 and 87,300, respectively. Both these industries, however, engaged between five and six thousand fewer of these personnel in 1979 than they had 10 years earlier. Since these two industries are the largest recipients of Federal funds for research and development, this decrease can be attributed, in part, to the slowdown in Federal financing of industrial R&D activities. On the other hand, each of the three other industries — chemicals, machinery, and motor vehicles — was employing at least 25 percent more R&D scientists and engineers than it had in January 1970, with the machinery industry showing a gain of 50 percent. Employment in the aircraft and missiles industry leveled off during 1979, although there were significant increases in each of the three previous years. In contrast, the electrical-equipment industry, which had been undertaking a massive drive to recruit new electrical engineering graduates, showed a gain of 9 percent between January 1979 and January 1980.

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Research and Development in Industry, 1979 (Detailed Statistical Tables) and a final report will be published later this year. The final analytical report is published biennially and *Science Resources Studies Highlights* and Tables are published each year. All are available from the National Science Foundation, Washington, D.C. 20550.

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